

Remarks

Claims 1-11, 17-22, 25-31, 32, 34, 37, 39-46 and 51 are pending in this application. Claims 12-16, 23, 24, 35, 36, and 38 are withdrawn as being drawn to a non-elected species and claims 47-50 are canceled as being drawn to a non-elected invention. The cancellation of this subject matter is without prejudice to pursuing it in a continuing application.

Claims 28 and 43 have been amended to further clarify the invention. Specifically, claim 28 has been amended to recite that steps (b) and (c) comprise exposing the substrate to a reducing agent and a tungsten-containing precursor, respectively and that steps (b) and (c) are performed sequentially in any order and together form a tungsten layer. Support for this amendment may be found at page 11, lines 23-25. Applicants have further amended claim 28 to incorporate the limitations of former claim 33. Claim 33 has been canceled and claim 34 has been amended to reflect the amendment to claim 28. Applicants have amended claim 43 to specify that the PNL tungsten and CVD tungsten are deposited at "one or more stations," that the tungsten is deposited on the substrate and to replace "reactor" with "reaction chamber."

Claim 51, directed to forming a sacrificial layer by "decomposing a borane compound on the semiconductor substrate," has been added. Support for this claim may be found at page, 3 lines 10-12. Claim 52 directed to multi-station deposition of tungsten nitride has also been added. Support for this claim may be found at page 10, lines 1-3 and at original claim 43.

No new matter has been added.

Election/Restriction

Applicants affirm the election of species Ic of invention I, claims 1-11, 17-22, 25-34, 37 and 39-46.

Rejections under 35 USC § 112

Claims 32 and 43 have been rejected under 35 USC § 112, second paragraph as being indefinite.

The Examiner states that it is not clear from claim 32 how the layer of reducing agent can be exposed to a tungsten-containing precursor when it is not yet formed by step (b). Applicants have amended claim 28 to specify that steps (b) and (c) comprise exposing the substrate to a reducing agent and a tungsten-containing precursor, respectively and that steps (b) and (c) may be performed sequentially in any order and together form a tungsten layer. Applicants believe

that this amendment makes clear that claim 32 is directed to a version of this process where exposure to the tungsten-containing precursor is performed prior to exposure to the reducing agent.

The Examiner states that it is not clear from claim 43 whether PNL tungsten and CVD tungsten are deposited or not or where the tungsten is deposited, and that “reactor” lacks antecedent basis. Applicants have amended claim 43 to specify that the PNL tungsten and CVD tungsten are deposited at “one or more stations,” that the tungsten is deposited on the substrate and to replace “reactor” with “reaction chamber.” Applicants believe these amendments obviate the rejections.

Rejection under 35 USC § 102

Claim 32 has been rejected under 35 USC § 102(b) as being anticipated by Elers et al. WO 01/27347 (“Elers”). As indicated above, applicants have amended claim 28, from which claim 32 depends, to incorporate the limitations of former claim 33. Specifically claim 28 has been amended to recite that one or more of the reducing agent, the tungsten containing precursor, and the nitriding agent comprise a different compound when employed to form the first portion of the tungsten nitride layer and when employed in (e).

As this feature is not taught or suggested by Elers and the Examiner has indicated that the subject matter of claim 33 is allowable, Applicants believe that this amendment obviates the rejection.

Rejections under 35 USC § 103

Claims 1-11, 17-22, 25-31, 37, 39-43, 45 and 46 have been rejected under 35 USC § 103(a) as being unpatentable over Matsuse et al. US Patent No. 6,861,356 (“Matsuse”) in view of Lee et al., US Patent No. 6,635,965 (“Lee”). Claims 26 and 44 have been rejected under 35 USC § 103(a) as being unpatentable over Matsuse in view of Lee and further in view of one of Chen et al. US Patent No. 6,607,976 (“Chen”) and Yoon et al. US Patent No. 6,740,585 (“Yoon”).

Applicants are submitting a statement with this response that the present application and the subject matter of Lee were commonly owned by or subject to assignment to Novellus Systems, Inc. at the time the present invention was made. Lee may not be used to support a § 103 rejection of the present application because it and the present invention were commonly

owned or subject to an obligation of assignment at the time the present invention was made. 35 USC § 103(c). Accordingly, Applicants request the Examiner withdraw the 35 USC § 103 rejections.

Claims 1-8, 18-19, 27-29, 31, 43 and 45 have been rejected under 35 § 103(a) as being unpatentable over Elers. Elers teaches an ALD process of forming a transition metal nitride film by first depositing a metal source metal, then a reducing agent and a nitrogen source material.

Claims 1-8, 18-19 and 27 are directed to a method of forming a tungsten nitride film on a substrate comprising contacting a substrate with reducing agent, tungsten containing precursor, and nitriding agent. Importantly, the method also includes the step of forming an initial boron-containing sacrificial layer on the substrate. The formation of the boron-containing sacrificial layer on the substrate has been found to be particularly good for subsequent PNL deposition of tungsten nitride, possibly because of the interactions with the dielectric surface (page 14, lines 15-21).

After formation, the sacrificial layer is exposed to a tungsten containing precursor to form a tungsten layer which is then exposed to a nitriding agent to form a first portion of a tungsten nitride layer. Additional cycles of tungsten nitride deposition comprising contact with a reducing agent, tungsten containing precursor and nitriding agent are performed. Although the reactions following the formation of the sacrificial layer are typically self-limiting (PNL) processes, the sacrificial layer formation process is not typically a conventional self-limiting ALD or PNL type deposition process. Rather, the boron-containing precursor typically reacts on the dielectric surface to decompose into a boron film. The reaction can proceed as long as the substrate is continually exposed to the boron-containing precursor (page 8, lines 22-24).

With respect to independent claim 1, the Examiner states Elers contends that the claimed invention is obvious over Elers since selection of any order of performing process steps is prima facie obvious in the absence of new or unexpected results.

Applicants submit that the claimed method is not prima facie obvious over Elers for at least the following reasons: 1) Elers does not contain each and every element of the claimed method, 2) merely interchanging the metal source material and reducing agent steps of Elers would not result in the claimed invention and 3) one of skill in the art would have no motivation for modifying Elers as suggested by the Examiner.

Elers is directed to ALD deposition based on "deposition of vaporized material onto a surface is based on sequential self-saturating surface reactions" (page 5, lines 25-27). The molecules of the reducing compound react with the deposited metal source compound layer at conditions where the reactions are self-saturated (page 8, lines 4-5). Thus, Elers teaches that all

of the reactions (the initial adsorption of a metal source material on the substrate and reduction by a boron compound) are conventional self-limiting ALD reactions. Elers specifically states that reaction conditions should be such that thermal decomposition of the reducing agent is to be avoided (page 10, lines 8-11). Nowhere does Elers teach or suggest forming an initial sacrificial layer on the substrate.

Moreover, one would not arrive at the claimed invention by simply interchanging the metal-containing compound and reducing agent steps of Elers. As discussed in Applicants' specification, one difference between PNL and ALD is that deposition of diborane in boron-based PNL-WN, B_2H_6 deposition is not a self-limiting process, but rather a real CVD process (page 13, lines 35-36). Formation of the sacrificial layer requires particular process conditions (pressure, temperature, dose, concentration, and time) to deposit a sufficient quantity of boron on the substrate surface (page 5, line 34-page 6, line 2). Given that the Elers teaches reducing agent step conditions that result in no thermal decomposition of the reducing agent (page 10, lines 8-11), simply performing the reducing agent step taught in Elers prior to the metal-containing source deposition would not result in formation of a sacrificial layer.

Finally, in view of Elers, one of skill in the art would have no motivation for forming the sacrificial layer of a boron-containing compound. As indicated above, Elers contemplates only ALD self-saturated surface reactions, which "require neither strict temperature control...nor precise dosage control of the source chemicals" (page 2, line 8-11). As explained in Applicants' specification, because the formation of the boron sacrificial layer is not a self-limiting reaction, it must be carefully limited (page 14, lines 28-31). Thus, upon reading Elers, one of skill in the art would not be motivated to form a sacrificial layer. It is only with Applicants' discovery that PNL works particularly well on a sacrificial layer of a boron-containing compound that one would be motivated to form one. Given the very different types of deposition under consideration in Elers and the formation of the sacrificial layer in the present invention, Applicants submit that one of skill in the art would not be motivated to modify Elers as the Examiner suggests.

For at least the reasons given above, independent claim 1 and dependent claims 2-8, 18-19 and 27 are patentable over the cited art. In addition, applicants have added dependent claim 51, which specifies that the sacrificial layer is formed by decomposing a boron compound on the substrate. As there is no teaching or suggestion in Elers of decomposing a boron compound to form a sacrificial layer, Applicants submit that claim 51 is independently patentable over Elers.

As discussed above, claim 28 has been amended to incorporate the features of former claim 33, which the Examiner acknowledged as allowable subject matter. Thus, claim 28 and claims 29, 31, 43 and 45, which depend from claim 28, are patentable over the cited art.

Accordingly, Applicants request that the Examiner withdraw these 35 USC § 103(a) rejections.

Claim Objections

Claims 17, 33 and 34 were objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form. Claim 33 has been canceled and claim 28 has been amended to incorporate the limitations of former claim 33. This amendment overcomes the objection to claim 34, which depends from claim 28. Applicants believe that the objection to claim 17 has been overcome by the arguments present above with respect to claim 1. Accordingly Applicants request that the Examiner withdraw these objections.

Conclusion:

In light of the foregoing amendments and remarks, Applicants respectfully submit that all pending claims are now in condition for allowance. Thus, Applicants respectfully request a Notice of Allowance from the Examiner. Should any unresolved issues remain, the Examiner is encouraged to contact the undersigned at the telephone number provided below. No fees appear to be necessary for this Amendment. However, if the Commissioner determines that any fee is due, such fee may be charged to deposit account No. 50-0388 (Order No. NOVLP063).

Respectfully submitted,
BEYER WEAVER & THOMAS, LLP



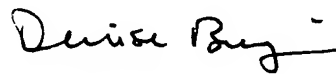
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**STATEMENT CONCERNING COMMON OWNERSHIP OF US APPLICATION NO.
NO. 10/690,492 AND U.S. PATENT NO. 6,635,965**

Applicants' undersigned representative states that the subject matter in US Application No. 10/690,492 and U.S. Patent No. 6,635,965 was owned by or subject to an obligation of assignment to Novellus Systems, Inc. at the time of the invention of Application No. 10/690,492 was made.

Respectfully submitted,
BEYER WEAVER & THOMAS, LLP

A handwritten signature in black ink, appearing to read "Denise Bergin". The signature is fluid and cursive, with a long horizontal stroke at the end.

Denise Bergin
Registration No. 50,581